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DESCRIPTION

INTERNAL GEAR FORMING METHOD AND INTERNAL GEAR

Technical Field

This invention relates to a method for forming an internal gear having a helical tooth and an internal gear formed by this forming method.

Background Art

One example of a method for forming an internal gear is described in the Official Gazette of Japanese Patent Publication No. H08-11264 and in the Official Gazette of Japanese Patent Application Laid-Open No. H09-26869. In case an internal gear is to be formed by a method described in those Official Gazettes, first, a cylindrical raw material is externally inserted onto a forming die having an outer gear part and fixed thereto. With a forming roll, which is rotatable about its own axis, pressed against the outer peripheral surface of the raw material, the forming roll is moved from one end side of the raw material to the other end side and relatively revolved about the axis of the forming die. By this, the inner peripheral surface of the raw material is pressed against the outer gear part to form an internal gear part corresponding to the outer gear part on the inner peripheral surface of the raw material.

The above conventional method for forming an internal gear has no problem in forming a spur gear whose tooth trace is in parallel relation to the axis of the internal gear. However, when this method is used for forming an internal gear having a helical tooth, a defective flow of the substantial part (solid part) of the gear raw material at the forming time occurs depending on the relation between the helical

direction of the tooth and the rotating direction of the forming die. As a result, it is difficult to form an internal gear having a teeth of high precision.

Disclosure of the Invention

According to a first mode of the present invention, there is provided a method for forming an internal gear in which a cylindrical raw material is externally inserted onto a forming die with an outer gear part formed thereon and fixed to the forming die, a forming roll is relatively moved in an axial direction of the forming die with respect to the raw material with the forming roll press-contacted with an outer peripheral surface of the raw material and relatively revolved about the axis of the forming die such that an inner peripheral surface of the raw material is pressed against the outer gear part of the forming die, thereby forming an internal gear part on the inner peripheral surface of the raw material, wherein each tooth of the outer gear part of the forming die is formed in a helical tooth, an annular weir part having an inside diameter equal to or less than a tooth tip circle diameter of the internal gear part is formed on the inner peripheral surface of the raw material adjacent to a second end part of the outer gear part on a rear side in a moving direction of the forming roll, and the forming die is rotated such that a first end part of the outer gear part on a front side in the moving direction of the forming roll is moved ahead of the second end part of the outer gear part on the weir part side when the forming roll is fixed and the forming die is rotated.

It is preferable that a tooth tip circle diameter and a tooth bottom circle diameter of the outer gear part of the forming die are gradually reduced from one end side on the weir part side toward the other end side of the outer gear part, and the tooth thickness of the outer gear

part is gradually reduced from one end side toward the other end side of the outer gear part in correspondence with the tooth tip circle diameter and tooth bottom circle diameter.

It is also preferable that an annular forming surface having a circular configuration in section about an axis of the forming die is formed at a place more offset toward the weir part side from the outer gear part on the outer peripheral surface of the forming die, and the forming roll is relatively revolved with respect to the forming die with the forming roll stopped at a location corresponding to the annular forming surface, so that the inner peripheral surface of the raw material is pressed against the annular forming surface, thereby forming an annular reference surface on the inner peripheral surface of the internal gear.

It is also preferable that the forming roll is relatively revolved in the normal and reverse directions at the time the forming roll is relatively revolved with respect to the forming die with the forming roll stopped at a location corresponding to the annular forming surface.

It is also preferable that the forming roll is separated in the radial direction from an outer peripheral surface of the cylindrical part before the forming roll is escaped from the outer peripheral surface of the raw material on the front side in the moving direction of the forming roll.

It is also preferable that the forming roll is relatively revolved a plurality of times with the forming roll stopped at a location where the forming roll is separated in the radial direction from the outer peripheral surface of the raw material.

According to a second mode of the present invention, there is provided an internal gear including a cylindrical part formed at an inner peripheral surface thereof with an internal gear part having a

helical tooth part, and a bottom part formed on one end part of the cylindrical part, wherein the internal gear part is formed on the inner peripheral surface of the internal gear and the annular reference surface is formed on the inner peripheral surface of the internal gear part between the bottom part and the internal gear part in accordance with the following forming methods A and B.

A. A method for forming an internal gear is employed in which a cylindrical raw material is externally inserted onto a forming die formed with an outer gear part and fixed thereto, a forming roll is relatively moved in the axial direction of the forming die with respect to the raw material with the forming roll press contacted with the outer peripheral surface of the raw material and relatively revolved about the axis of the forming die, so that the inner peripheral surface of the raw material is pressed against the outer gear part of the forming die, thereby forming an internal gear part on the inner peripheral surface of the raw material, each tooth of the outer gear part of the forming die is formed in a helical tooth, and an annular weir part having an inside diameter equal to or less than a tooth tip circle diameter of the internal gear part is formed on the inner peripheral surface of the raw material adjacent to a second end part of the outer gear part on a rear side in a moving direction of the forming roll, and the forming die is rotated such that a first end part of the outer gear part on a front side in the moving direction of the forming roll is moved ahead of the second end part of the outer gear part on the weir part side when the forming roll is fixed and the forming die is rotated, thereby forming the internal gear part.

B. Said forming die is formed at a place more offset toward the weir part side from the outer gear part on the outer peripheral surface with an annular forming surface having a circular configuration in section about an axis of the forming die, and the forming roll is relatively revolved with respect to the forming die with the forming roll stopped at a location corresponding to the annular forming surface, so that the inner peripheral surface of the raw material is pressed against the annular forming surface, thereby forming an annular reference surface on the inner peripheral surface of the internal gear.

Brief Description of Drawings

FIG. 1 is a side sectional view showing one example of an internal gear formed by a forming method according to the present invention.

FIG. 2 is a side sectional view showing a raw material which is used when the internal gear shown in FIG. 1 is formed by a forming method according to the present invention.

FIG. 3 is a side sectional view showing a forming die, a raw material and a pressing die which are used in a forming method according to the present invention.

FIG. 4 is a side sectional view showing a standby state of a forming roll for forming a raw material which is fixed to the forming die shown in FIG. 3 by the pressing die.

FIG. 5 is a side sectional view showing a state in which a reference surface of the internal gear is being formed by the forming roll.

FIG. 6 is a side sectional view showing a state immediately before the completion of the forming process of the internal gear by using the forming roll.

FIG. 7 is a side sectional view showing an internal gear formed body obtained by removing the raw material formed by the forming roll from the forming die.

Best Mode for Carrying Out the Invention

The best modes for carrying out the invention will be described hereinafter with reference to FIGS. 1 through 7.

First, an internal gear formed in accordance with a forming method of the present invention will be described. FIG. 1 is a vertical sectional view taken by a plane including an axis of an internal gear formed by a forming method of the present invention. The internal gear 1 shown in FIG. 1 comprises a cylindrical part 1a having constant inside and outside diameters, and a bottom part 1b integrally formed with one end part of the cylindrical part 1a. Of the entire inner peripheral surface of the cylindrical part 1a, the range of area from an open end of the cylindrical part 1a to the vicinity of the bottom part 1c is formed with an internal gear part 1c. This internal gear part 1c is formed such that its axis is aligned with that of the cylindrical part 1a. The internal gear part 1c includes a helical tooth. The helical direction of each tooth of the internal gear part 1c is set such that when the internal gear 1 is rotated in the clockwise direction (the direction as indicated by an arrow of FIG. 1) as viewed in the direction of the bottom part 1b side, the end part, on the opening part side of the internal gear 1, of each tooth of the internal gear part 1c is moved ahead in the rotating direction of the end part on the bottom part 1b side. Of course, the helical direction of the internal gear part 1c may be in the reversed direction to the direction of this first mode of the invention.

The end part on the bottom part 1b side of the internal gear part 1c is formed in a tapered part 1d which is inclined in such a manner as

to approach the bottom part 1b toward the tooth tip side from the tooth bottom side. On the other hand, the end part of the internal gear part 2c on the opening part side of the internal gear 1 is defined as an incomplete tooth part 1e having a generally circular configuration in section. One end of the incomplete tooth part 1e on the bottom part 1b side is smoothly contacted with a tooth tip surface (inner peripheral surface) 1j of the internal gear part 1c, and the other end of the incomplete tooth part 1e on the opening part side of the internal gear 1 is intersected with an end face 1f on the opening side of the cylindrical part 1a at the tooth bottom or at a place offset toward the outer periphery side of the cylindrical part 1a from the tooth bottom.

At a place between the internal gear part 1c on the inner peripheral surface of the cylindrical part 1a and the bottom part 1b, an annular reference surface (weir part) 1g which is short in length is formed. This reference surface 1g is formed such that its axis is aligned with the axes of the cylindrical part 1a and the internal gear part 1c, and it has an inside diameter equal to the tooth tip circle (inside diameter of the internal gear part 1c) of the internal gear part 1c. The reference surface 1g may be more reduced or enlarged in diameter than the tooth tip circle of the internal gear part 1c. In case the inside diameter of the reference surface 1g is made equal to or less than that of the internal gear part 1c, the reference surface 1g can also serve as a weir. However, in case the inside diameter of the reference surface 1g is made larger than that of the tooth tip circle of the internal gear part 1c, the reference surface 1g cannot serve as a weir. In such a case, it is necessary that the reference surface 1g is arranged in such a manner as to be separated away from the internal gear part 1c toward the bottom part 1b side, and an annular weir part having an inside diameter equal to or less than the diameter of the tooth tip circle of the internal gear

part 1c and with its axis aligned with that of the internal gear part 1c is formed, as a separate body, at a place adjacent to the internal gear part 1c between the reference surface 1g and the internal gear 1c. The operation of the reference surface 1g and the weir which is also commonly served by the reference surface 1g will be described later.

A spline hole 1h is formed at a central part of the bottom part 1b. The spline hole 1h is formed such that it pierces the bottom part 1b and its axis is aligned with those of the cylindrical part 1a and the internal gear part 1c. The axis of the spline hole 1h can be made in alignment with that of the internal gear part 1c by machining the spline hole 1h, for example, by a pinion cutter with the internal gear 1 positioned and fixed with reference to the reference surface 1g, or by broach machining the spline hole 1h following its reference inside diameter after the reference inside diameter of the spline hole 1h is formed. An annular protrusion 1i is formed on an end face opposite to the cylindrical part 1a of the bottom part 1b. This annular protrusion 1i has a smaller outside diameter than that of the cylindrical part 1a, and it is formed such that its axis is aligned with that of the cylindrical part 1a.

Next, a method for forming the internal gear 1 will be described. FIG. 2 is a sectional view showing a raw material 2 which is used at the time for forming the internal gear 1. This gear raw material 2 has a bottomed cylindrical configuration as a whole. The gear raw material 2 includes a tapered cylindrical part 2a and a bottom part 2b integrally formed with the end part on the reduced-diameter side of the cylindrical part 2a.

The cylindrical part 2a is formed at an inner peripheral part thereof with the reference surface forming part 2c, the tapered part 2d and the internal gear forming part 2e which are all formed in this order from the bottom part 2b side toward the opening part side of the

cylindrical part 2a such that the axes of them are aligned with the axis with the cylindrical part 2a. The reference surface forming part 2c is formed as a straight hole having a circular configuration in section which is short in length. The length of the reference surface forming part 2c is set to be generally equal to the length of the reference surface 1g of the internal gear 1, and the inside diameter of the part 2c is set to be generally equal to or slightly larger than that of the reference surface 1g. The tapered part 2d has a same taper angle as the tapered part 1d and is gradually enlarged in diameter from the reference surface forming part 2c toward the opening part side of the cylindrical part 2a. Accordingly, the inside diameter of the reduced-diameter side end part of the tapered part 2d is equal to that of the reference surface forming part 2c. On the other hand, the inside diameter of the enlarged-diameter side end part of the tapered part 2d is set to be generally equal to or slightly larger than the tooth tip circle diameter of the internal gear part 1c. The internal gear forming part 2e extends from the tapered part 2d to the opening end of the cylindrical part 2a while being gradually enlarged in diameter with a smaller taper angle than the tapered part 2d. Accordingly, the inside diameter of the reduced-diameter side end part of the internal gear forming part 2e is equal to or slightly larger than the tooth bottom circle diameter of the internal gear part 1c, and the inside diameter of the enlarged-diameter side end part of the internal gear forming part 2e is larger than the tooth bottom circle diameter of the internal gear part 1c. Instead of being formed into a tapered state, the internal gear forming part 2e may be formed as a straight hole having a slightly larger diameter than the tooth bottom circle diameter of the internal gear part 1c.

The outer peripheral surface 2g of the cylindrical part 2a has a generally same taper angle as the internal gear forming part 2e. Accordingly, the cylindrical part 2a is generally constant in thickness at its part corresponding to the internal gear forming part 2e. The thickness of the cylindrical part 2a at its part corresponding to the internal gear forming part 2e and the length of the cylindrical part 2a are determined taking into consideration of the axial elongation of the cylindrical part 2a at the time of completion of forming the internal gear part 1c on the inner peripheral surface of the cylindrical part 2a. A biting part 2h, which is gradually enlarged in diameter from the bottom part 2b side toward the cylindrical part 2a side, is formed on the outer peripheral surfaces at the intersecting part between the cylindrical part 2a and the bottom part 2b. The taper angle of this biting part 2h is set to be generally equal to that of the tapered part 2d. Accordingly, the thickness of the intersecting part between the cylindrical part 2a and the bottom part 2b is generally constant and generally equal to that of the cylindrical part 2a.

An annular protrusion 2i is formed on the opposite end face to the cylindrical part 2a side of the bottom part 2b such that its axis is aligned with that of the cylindrical part 2a. This annular protrusion 2i has the same dimension as the annular protrusion 1i of the internal gear 1, but the length in the axial direction of the annular protrusion 2i may be set to be longer by its finishing portion than that of the annular protrusion 1i. A prepared hole 2j is formed at a central part of the bottom part 2b such that the prepared hole 2j pierces the bottom part 2b. The inside diameter of this prepared hole 2j is more reduced in diameter by a finishing width portion at the time of pinion cutter or broach machining than the inside diameter (tooth tip circle diameter) of the spline hole 1h.

In case the internal gear 1 is formed from the raw material 2, a forming die 3, a pressing die 4 and a forming roll 5 are used as shown in FIGS. 3 and 4.

The forming die 3 has a circular shaft-like configuration in section and is rotated in the normal and reverse directions about its axis by rotation driving means (not shown). An annular forming surface 3a and an outer gear part 3b are sequentially formed on the outer peripheral surface of the forming die 3 from one end (left end in FIG. 3) of the forming die 3 toward the other end side with their axes aligned with the axis of the forming die 3. The annular forming surface 3a has the same dimension as the reference surface 1g of the internal gear 1. The outer gear part 3b has the same helical angle as the internal gear part 1c. A tooth part of the outer gear part 3b as its solid part and a tooth groove part of the outer gear part 3b as its space part have the generally same configurations as the tooth groove part and the tooth part of the internal gear part 1c. More specifically, the tooth tip circle diameter (outside diameter), the tooth bottom circle diameter, the tooth thickness and the tooth gap of the outer gear part 3b at the end part connecting with the annular forming surface 3a are same in dimension as the tooth bottom circle diameter, the tooth tip circle diameter, the tooth gap and the tooth thickness of the internal gear part 1c, respectively. However, the tooth tip circle diameter and the tooth bottom circle diameter of the outer gear part 3b are slightly reduced from one end side of the forming die 3 toward the other end side. In correspondence with this, the tooth thickness of the outer gear part 3b is also slightly reduced from one end side of the forming die 3 toward the other end side. The length of the outer gear part 3b is set to be sufficiently longer than the length of the internal gear part 1c. The end part adjacent to the annular forming surface 3a of the outer gear part 3b is formed as a tapered part 3c. This

tapered part 3c has the same dimension as the tapered part 1d of the internal gear 1.

The pressing die 4 has a circular shaft-like configuration in section, and its outer diameter is generally equal to the outside diameter (equal to the outside diameter of the annular protrusion 2i of the raw material 2) of the annular protrusion 1i of the internal gear 1. The pressing die 4 is movable in the directions toward and away from the forming die 3 and rotatable about its axis with its axis aligned with that of the forming die 3.

The forming roll 5 has a disc-like configuration and arranged such that its axis is parallel to that of the forming die 3. The forming roll 5 may be arranged such that its axis is in a helical positional relation to that of the forming die 3. The forming roll 5 is arranged such that it is rotatable about its own axis and movable in the axial direction of the forming die 3. An arcuate part 5a and a release part 5b are formed on the outer peripheral surface of the forming roll 5. The arcuate part 5a has a generally quarterly arcuate configuration in section and arranged at a front end part in the moving direction (the direction as indicated by an arrow B of FIG. 4) of the forming roll 5 at the time of forming the internal gear 1. One end part of the arcuate part 5a is connected with an end face 5c of the forming roll 5 directing in the direction as indicated by the arrow B. The other end of the arcuate part 5a is connected with the release part 5b. The release part 5b extends from the arcuate part 5a to the other end face 5d of the forming roll 5 and is gradually reduced in diameter from the arcuate part 5a toward the other end face 5d side. The minimum distance between the arcuate part 5a and the axis of the forming die 3 is set to be equal to the outside diameter of the cylindrical part 1a of the internal gear 1.

In case the internal gear 1 is to be formed using the raw material 2, the forming die 3, the pressing die 4 and the forming roll 5, the raw material 2 is externally inserted onto one end part (left end part in FIG. 4) of the forming die 3 as shown in FIGS. 3 and 4. Then, the annular forming surface 3a of the forming die 3 is fitted to the reference surface forming part 2c of the raw material 2 until one end face of the forming die 3 is contacted with the bottom part 2b. By this, the axis of the cylindrical part 2a of the raw material 2 is generally aligned with the axis of the forming die 3. Thereafter, the pressing die 4 is moved toward the forming die 3 so that the bottom part 2b of the raw material 2 is fixedly sandwiched between the left end face of the forming die 3 and the right end face of the pressing die 4 in FIG. 4. By this, the raw material 2 is fixed to the forming die 3. On the other hand, the forming roll 5 is, as shown, located at a place separated away toward the rear side (opposite side to the direction as indicated by the arrow B of FIG. 4) in the moving direction at the forming time with respect to the raw material 2 which is fixed to the forming die 3.

Subsequently, the forming die 3 is driven for rotation about its axis. In this case, the forming die 3 is driven for rotation in the direction as indicated by the arrow A of FIG. 4 so that a first end part (hereinafter, this end part is referred to as the front side end part) of each tooth of the outer gear part 3b located on the front side in the moving direction (the direction as indicated by the arrow B) of the forming roll 5 is moved ahead of a second end part (hereinafter, this end part is referred to as the rear side end part) of the outer gear part located at the rear side (reference surface (weir part) 1g side) in the moving direction. When the forming die 3 is driven for rotation, the raw material 2 and the pressing die 4 are rotated in the same direction following the forming die 3. Thereafter, the forming roll 5 is moved in

the direction as indicated by the arrow B. The forming roll 5 thus moved in the direction as indicated by the arrow B, is contacted with the biting part 2h of the raw material 2, first. When the forming roll 5 is contacted with the raw material 2, the forming roll 5 is rotated about its own axis by a frictional resistance between the forming roll 5 and the raw material 2 in accordance with the rotation of the raw material 2. Moreover, since the raw material 2 is rotated, it is relatively revolved with respect to the raw material 2. Thereafter, when the forming roll 5 is further moved in the direction as indicated by the arrow B, a part of the entire raw material 2 from the contacting part with the biting part 2h of the forming roll 5 to the front side part in the moving direction is formed into the cylindrical part 1a by the forming roll 5 in accordance with the movement of the forming roll 5.

When the place closest to the outer periphery of the forming roll 5 of the entire arcuate part 5a of the forming roll 5, is brought to a location opposing to the annular forming surface 3a of the forming die 3, the forming roll 5 is temporarily stopped moving in the direction as indicated by the arrow B. The forming die 3 is rotated while maintaining that condition. The reference surface forming part 2c of the raw material 2 is pressed against the annular forming surface 3a of the forming die 3. By this, the reference surface 1g of the internal gear 1 is formed. At the time of forming the reference surface 1g, the forming die 3 is preferably rotated a plurality of times. Particularly preferably, the forming die 3 is rotated a plurality of times in the normal and reverse directions, respectively. By doing so, the reference surface forming part 2c of the raw material 2 can be contacted well with the annular forming surface 3a of the forming die 3 and the reference surface 1g can be enhanced in precision.

Thereafter, the forming roll 5 is moved in the direction as indicated by the arrow B again and the forming die 3 is rotated in the direction as indicated by the arrow A of FIGS. 4 through 6. Then, the cylindrical part 2a of the raw material 2 is formed as the cylindrical part 1a of the internal gear 1, and the internal gear part forming part 2e of the raw material 2 is pressed against the outer gear part 3b of the forming die 3. By this, the internal gear part 1c is formed. That is, the tooth part of the outer gear part 3b is bitten into the internal gear part forming part 2e to thereby form the tooth groove part of the internal gear part 1c. Simultaneous with this, the solid part (substantial part) of the raw material 2 corresponding to a biting portion of the tooth part of the outer gear part 3b is flowed into the tooth groove part of the outer gear part 3b to thereby form the tooth part of the internal gear part 1c. In this case, a part of the solid part of the raw material 2 flown into the tooth groove part of the outer gear part 3b remains there but a part of the remainder tends to flow along the tooth groove of the outer gear part 3b.

Presuming that the forming die 3 is rotated such that the front side end part of the outer gear part 3b in the feeding direction of the forming roll 5 is located at a back side position in the rotating direction (the direction as indicated by the arrow A) of the forming die 3 against the rear side end part of the outer gear part 3b, in other words, when the forming die 3 is rotated in the reverse direction to the direction as indicated by the arrow A, a large part of the solid part of the raw material 2 flown into the tooth groove part of the outer gear part 3b is flown toward the opening part side of the raw material 2. As a result, the solid part of the raw material 2 is not sufficiently filled in the entire tooth groove part of the outer gear part 3b, and a sag or the like may be generated at the tooth part of the internal gear part 1c thus

formed. Moreover, as indicated by a phantom line of FIG. 5, an incomplete tooth part 1e' having an uneven length in the axial direction of the internal gear part 1c is formed on the internal gear forming part 2e located on a front side of the forming roll 5 by the solid part of the raw material 2 flown into the tooth groove part of the outer gear part 3b.

In this respect, in the forming method of the present invention, since the forming die 3 is rotated in the direction as indicated by the arrow A so that the front side end part of the outer gear part 3b in the feeding direction of the forming roll 5 is moved ahead of the rear side end part of the outer gear part 3b in the rotating direction of the forming die 3, the large part of the solid part of the raw material 2 flown into the tooth groove part of the outer gear part 3b is flown backward under the feeding effect of each tooth of the outer gear part 3b. Then, since the reference surface (weir part) 1g is formed at a place adjacent to the rear side end part of the internal gear part 1c, the solid part trying to flow backward is received by the reference surface 1g. As a result, the solid part of the raw material 2 is sufficiently filled in the entire tooth groove part of the outer gear part 3b. Hence, a tooth part, which is free from sag or the like and which is high in precision, is formed as a tooth part of the internal gear part 1c. In this way, formation of the tooth part of the internal gear part 3b made by the forming roll 5 is consecutively performed in accordance with the movement of the forming roll 5. Accordingly, the internal gear part 1c is formed with high precision over its entirety. Moreover, since only a part of the solid part of the raw material 2 is flown toward the opening part side of the raw material 2, the length of the incomplete tooth part 1e formed by the solid part can be reduced.

As shown in FIG. 6, when the forming roll 5 is brought to a place immediately before being escaped from the raw material 2 and as a

result, the incomplete tooth part 1e is brought to a place immediately before reaching the end face of the opening part of the raw material 2, the feeding movement in the direction as indicated by the arrow B of the forming roll 5 is stopped. In that condition, the forming die 3 is rotated a plurality of times. By this, the internal gear part 1c and the cylindrical part 1a can be enhanced in roundness. Thereafter, the forming roll 5 is moved radially outwardly of the forming die 3 so that it can be separated away from the raw material 2. When the forming roll 5 is separated away from the raw material 2, the pressing die 4 is moved away from the raw material 2 and the raw material 2 is removed from the forming die 3. By doing so, an entire internal gear forming body 6 as shown in FIG. 7 can be obtained. The internal gear forming body 6 has the same configuration as the internal gear 1 only excepting a non-formed part as a left non-formed part of the raw material 2 by the forming roll 5 and the prepared hole 2j.

Although the tooth tip circle diameter, the tooth bottom circle diameter and the tooth thickness of the forming die 3 are reduced from one end part on the annular forming surface 3a side toward the other side, the opening part side of the raw material 2 is enlarged in diameter by spring back when the forming roll 5 is separated away from the raw material 2. As a result, the tooth tip circle diameter, the tooth bottom circle diameter and the tooth groove width of the internal gear part 1c thus formed are increased. Accordingly, the raw material 2 can easily be removed from the forming die 3. Moreover, increasing amounts of the tooth tip circle diameter, the tooth bottom circle diameter and the tooth groove width of the internal gear part 1c caused by spring back correspond to amounts by which the tooth tip circle diameter, the tooth bottom circle diameter and the tooth thickness of the outer gear part 3b are reduced from one end part on the annular forming surface 3a side

toward the other end side. Accordingly, the internal gear part 1c becomes generally constant in tooth tip circle diameter, tooth bottom circle diameter, tooth thickness and tooth groove width from its one end toward the other end.

In case the internal gear forming body 6 is to be formed into the internal gear 1, the outer surface of the non-formed part 6a is cut off until its outside diameter becomes equal to the outside diameter of the cylindrical part 1a and the end face of the non-formed part 6a is cut off along a plane orthogonal to the axis of the internal gear forming body 6 so that the dimension between the end face of the non-formed part 6a and the left end face of the annular protrusion 1i becomes equal to the dimension between the end face 1f of the internal gear 1 and the end face of the annular protrusion 1i. By this, the end face 1f of the internal gear 1 is formed. This end face 1f is in contact with the tooth bottom of the incomplete tooth part 1e (internal gear part 1c) or slightly spaced apart rightward in FIG. 7 from the tooth bottom of the incomplete tooth part 1e. In this way, in case the end face of the incomplete part 6a is cut off so that the end face 1f will not intersect the tooth bottom of the internal gear part 1c, burr can be prevented from being generated at the end part of the internal gear part 1c. That is, if the internal gear part 1c should be formed upto the opening part side end part of the raw material 2, burr would be generated at the end part of the internal gear part 1c because the end part of the internal gear part 1c would be intermittently cut by a cutter when the end part of the raw material 2 is cut off in order to form the end face 1f. In this embodiment, however, since the end face 1f is in contact with the tooth bottom of the incomplete tooth part 1e or slightly spaced apart from the incomplete tooth part 1e, the internal gear part 1c is never cut in order to form the end face 1f at the time of cutting the end face of the non-

formed part 6a. Accordingly, burr can surely be prevented from being generated at the end part of the internal gear part 1c. Either of the cutting-off of the outer peripheral surface of the non-formed part 6a and the cutting-off of the end face of the non-formed part 6a may be carried out first.

The prepared hole 2j of the internal gear forming body 6 is formed into the spline hole 1h by pinion cutter or broach machining. At that time, the internal gear forming body 6 is positionally fixed with reference to the reference surface 1g and the pinion cutter machining, broach machining or the like is carried out. By doing so, the axis of the spline hole 1h can correctly be aligned with the axis of the internal gear part 1c. Machining of the prepared hole 2j may be carried out before or after the cutting-off machining of the non-formed part 6a is carried out.

The internal gear 1 is preferably subjected to surface hardening treatment after the completion of machining. Particularly, the internal gear part 1c is preferably subjected to surface hardening treatment. As the surface hardening treatment, there can be listed, for example, soft-nitriding treatment, nitriding treatment, carbonizing and quenching treatment, carbonizing and nitriding treatment, tempering and quenching treatment, and the like.

In the internal gear 1 formed in the manner as described above, the axis of the spline hole 1h can correctly be aligned with the axis of the internal gear part 1c at the time of broach machining the spline hole 1h to the bottom part 1b as previously mentioned. Moreover, the internal gear part 1c can be enhanced in precision and the length of the incomplete tooth part 1c in the axial direction of the internal gear 1 can be reduced. If it is a main object to merely enhance the precision of the internal gear 1, it can be contemplated that the internal gear part 1c, for example, is machined by a pinion cutter. However, in case the

internal gear part 1c is machined by a pinion cutter, it is necessary to form an annular recess groove whose diameter is larger than the tooth bottom circle diameter of the internal gear part 1c on the inner peripheral surface of the internal gear 1 between the internal gear part 1c and the bottom part 1b. Formation of such a recess groove results in reduced strength of the internal gear 1 because the part of the internal gear 1 where the recess groove is formed is reduced in thickness. In order to prevent such a reduced strength from occurring, the outside diameter of the internal gear 1 must be increased by a portion equal to a reduced portion of the thickness of the internal gear 1 caused by the recess groove formed thereon. However, it is not necessary for the internal gear 1 of the present invention to form a recess groove on the inner peripheral surface of the internal gear 1 between the internal gear part 1c and the bottom part 1b, and the thickness can be increased to that portion. Accordingly, the outside diameter of the internal gear 1 is not required to be increased and the internal gear 1 can be reduced in diameter.

The present invention should not be limited to the above embodiments but many changes and modifications can be made in accordance with necessity.

For example, in the above embodiments, the forming roll 5 is relatively revolved with respect to the raw material 2 by rotating the forming die 3. It is also accepted that the forming die 3 is non-rotatably fixed and the forming roll 5 is revolved around the raw material 2 about the axis of the forming die 3.

Moreover, although the forming roll 5 is moved in the axial direction of the forming die 3, it is also accepted that the forming roll 5 is positionally fixed and the forming die 3 is moved in the reverse

direction to the moving direction of the forming roll 5 in the above embodiments.

Industrial Applicability

This invention can be utilized as a method for forming an internal gear having a helical tooth. The internal gear formed by this forming method can be used as an internal gear of a planetary gear apparatus, for example.